

Zooming in on black holes: numerical-relativity follow-up to GW observations

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GR 21
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Binary black holes: what goes in

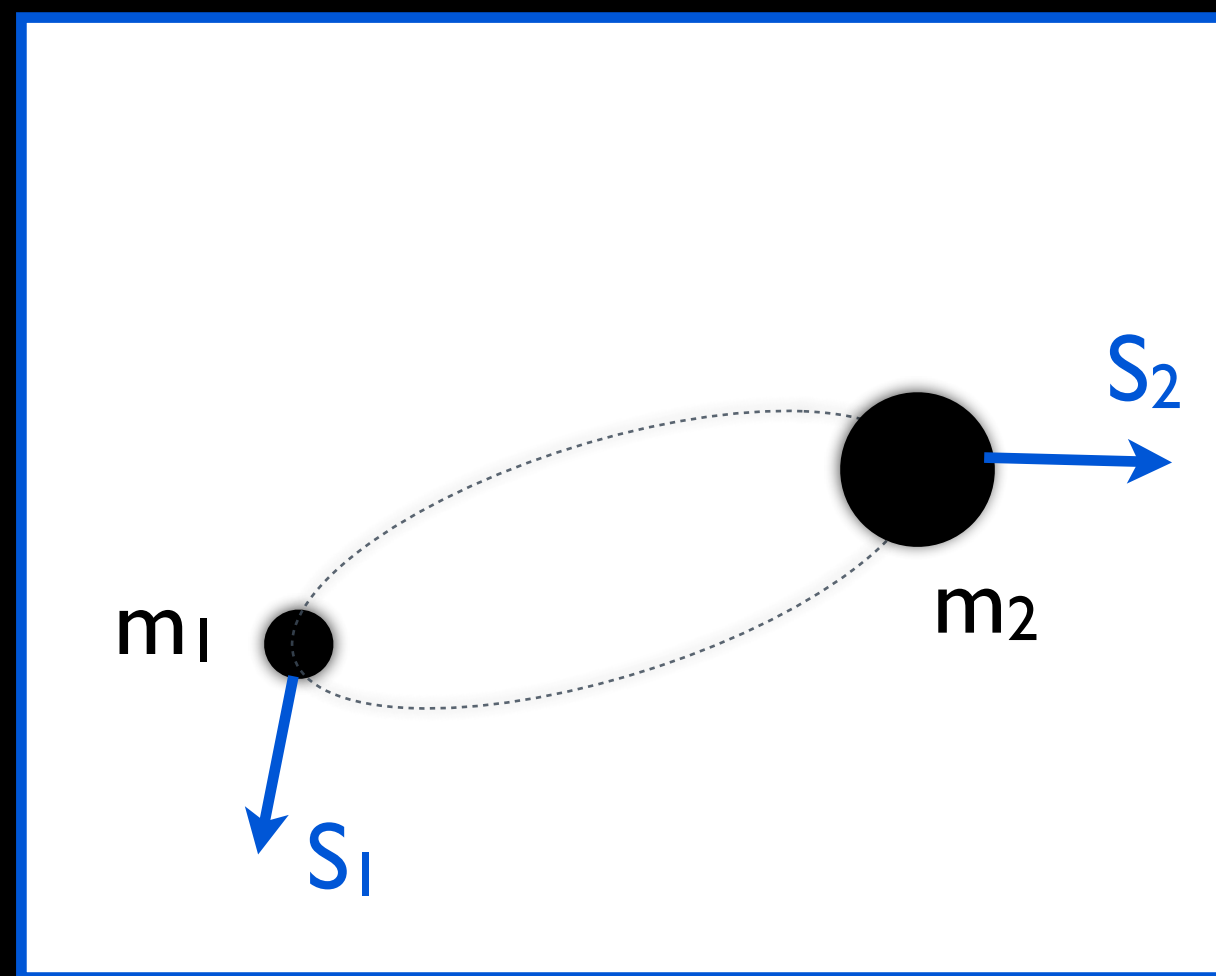
Masses: m_1, m_2

Spins: S_1, S_2

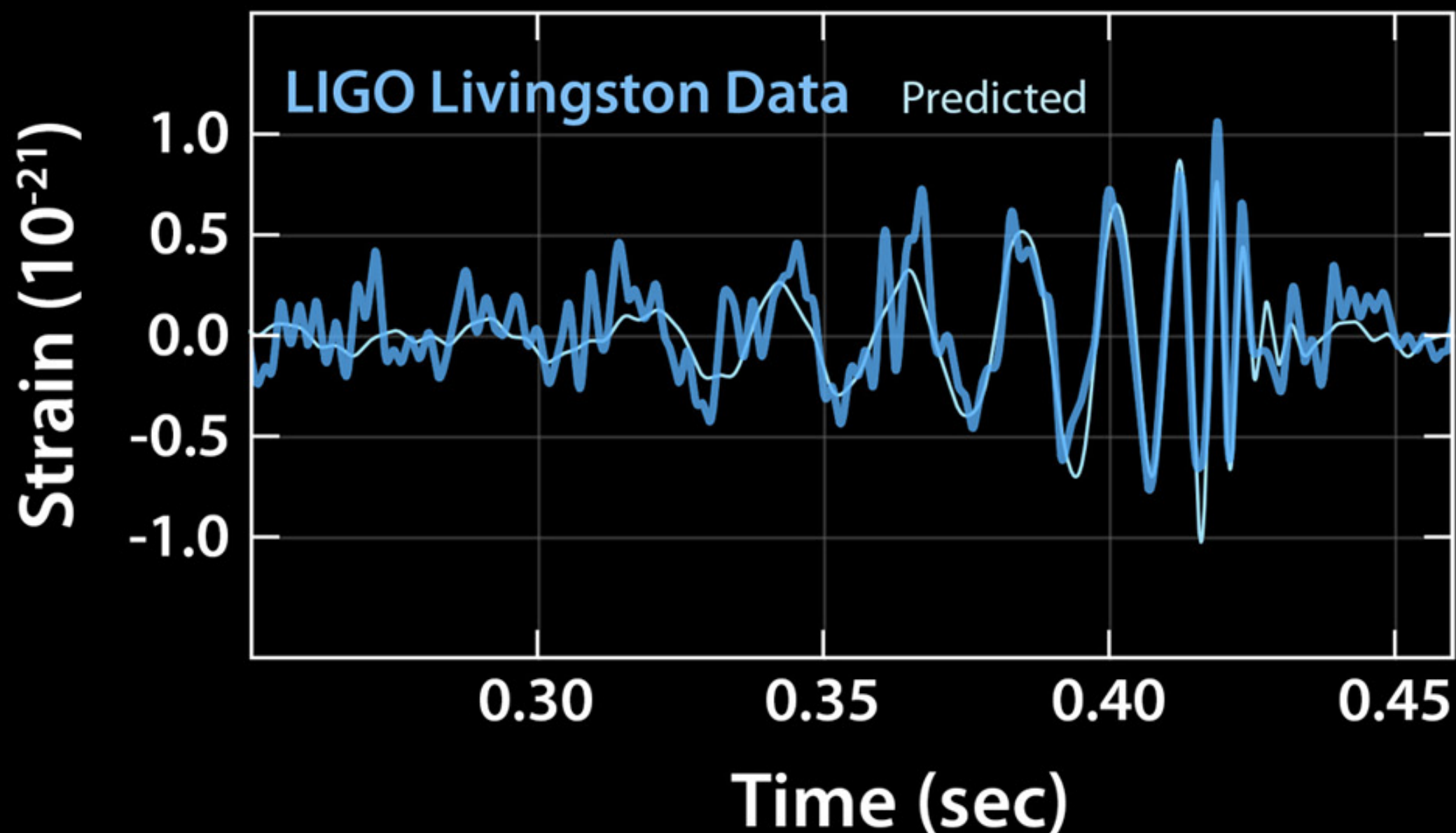
(8 parameters)

Plus:

distance, sky location,
orientation, polarisation



Binary black holes: what comes out



Merger models require NR simulations.

Precession models are very recent...

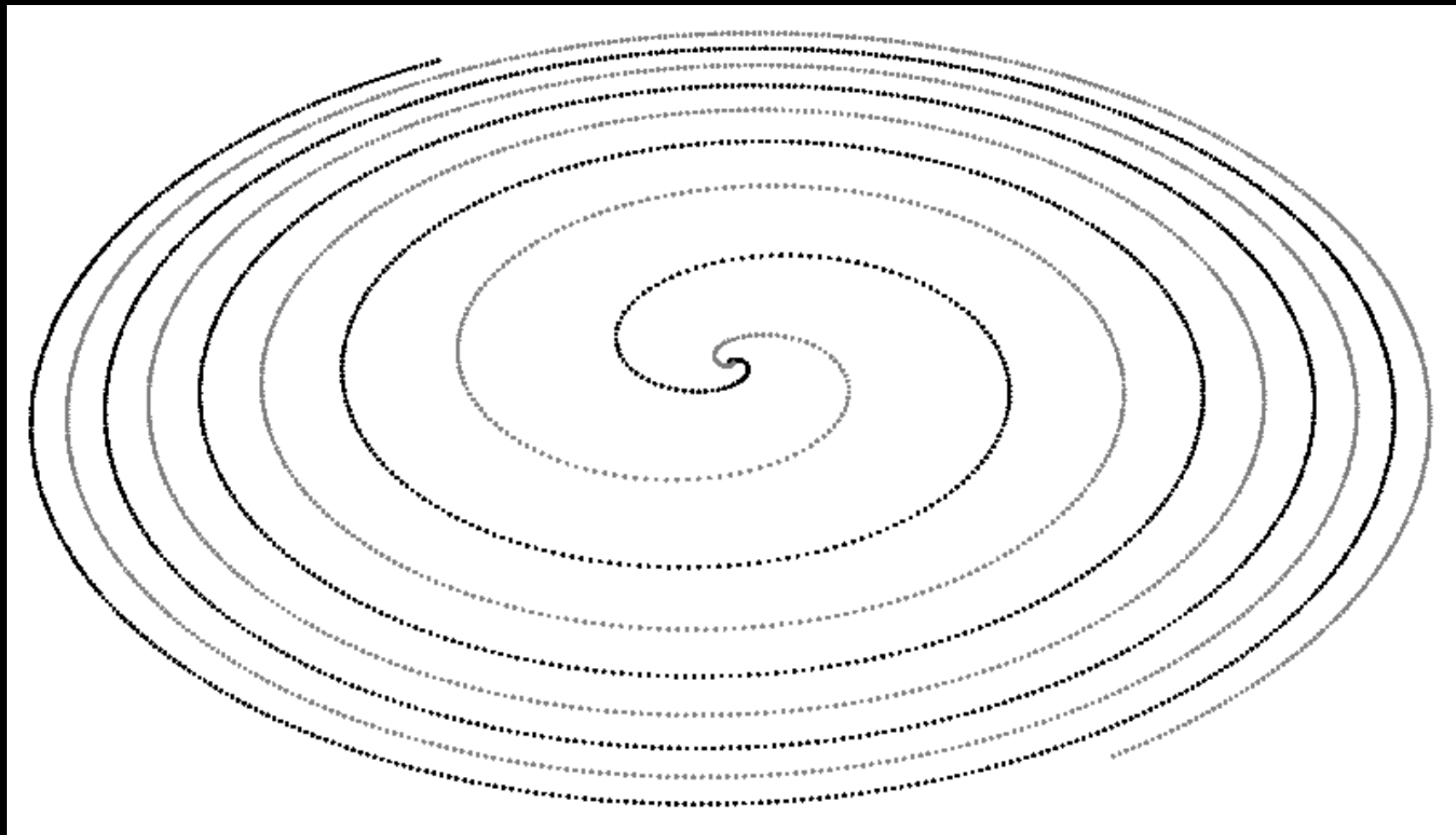
[Hannam, et. al. (2014);
Pan, et al. (2014), Taracchini, et. al. (2014)]

None are tuned to precessing NR simulations

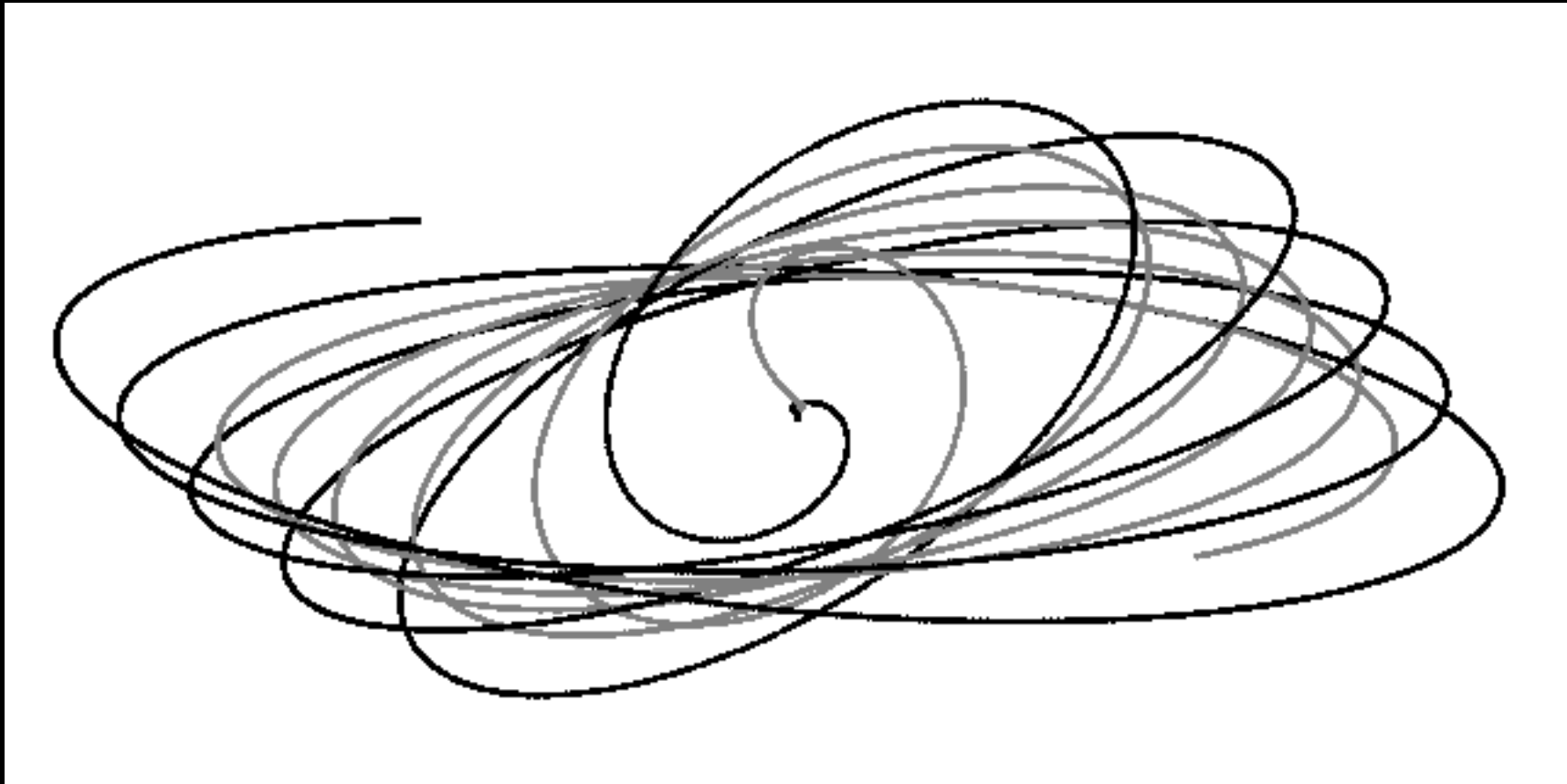
(See Sascha Husa's talk, Wednesday 2-4pm)

Many effects are masked by degeneracies...

Equal-mass nonspinning BBH consistent with GW150914

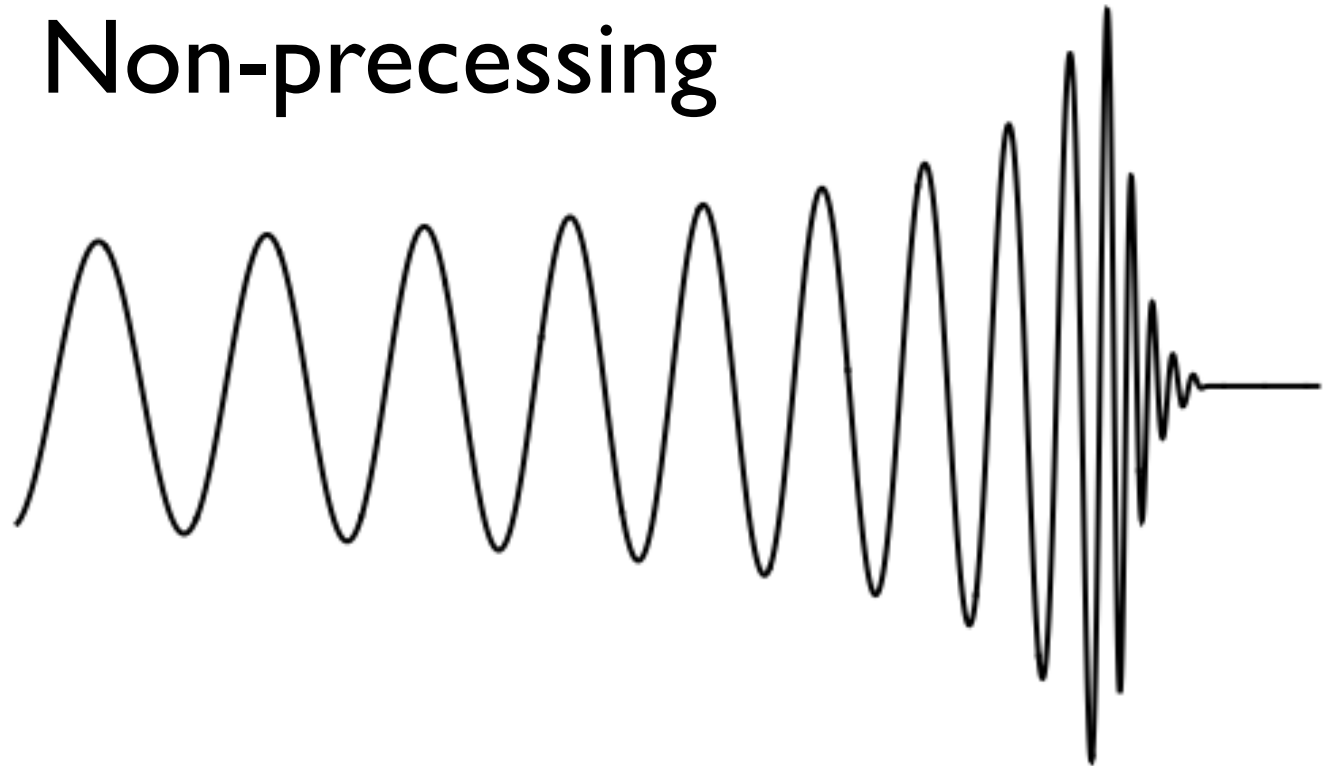


Unequal-mass precessing BBH consistent with GW150914

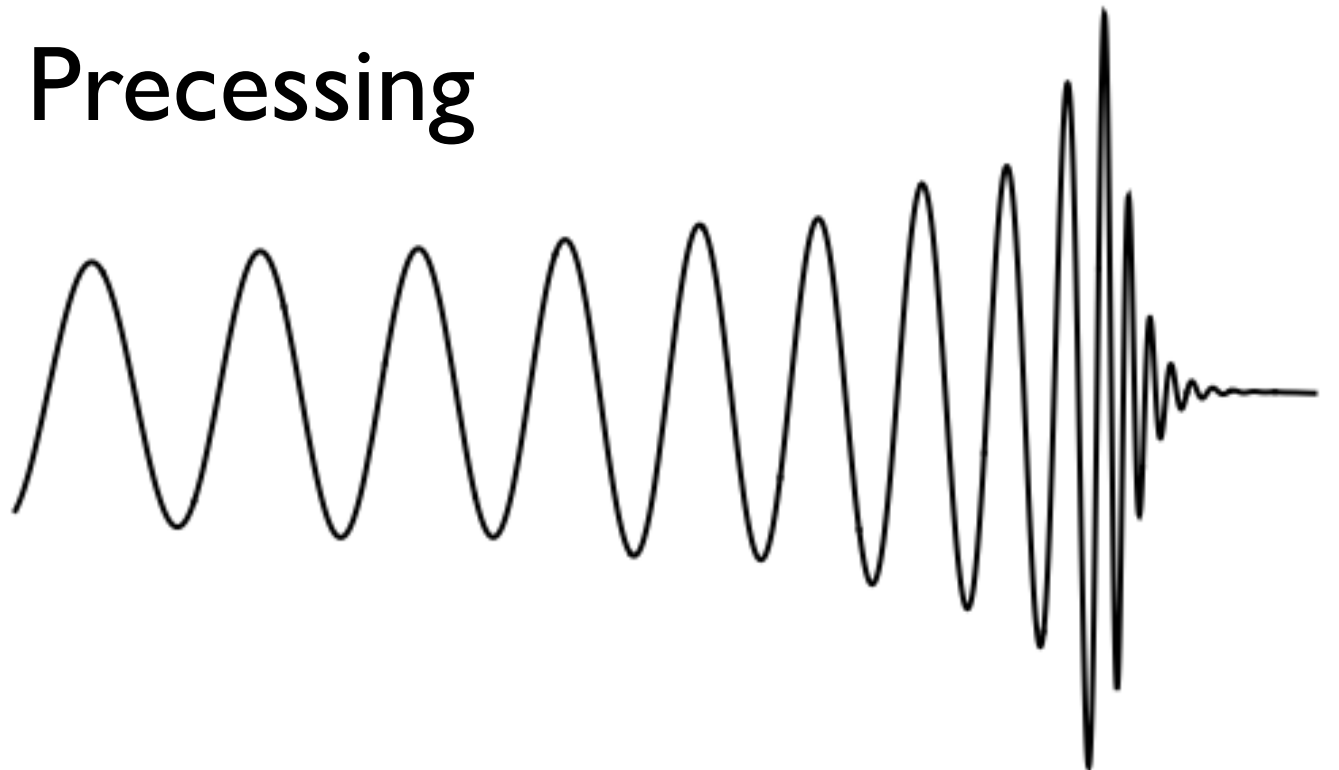


“Face-on”
to the
source

Non-precessing

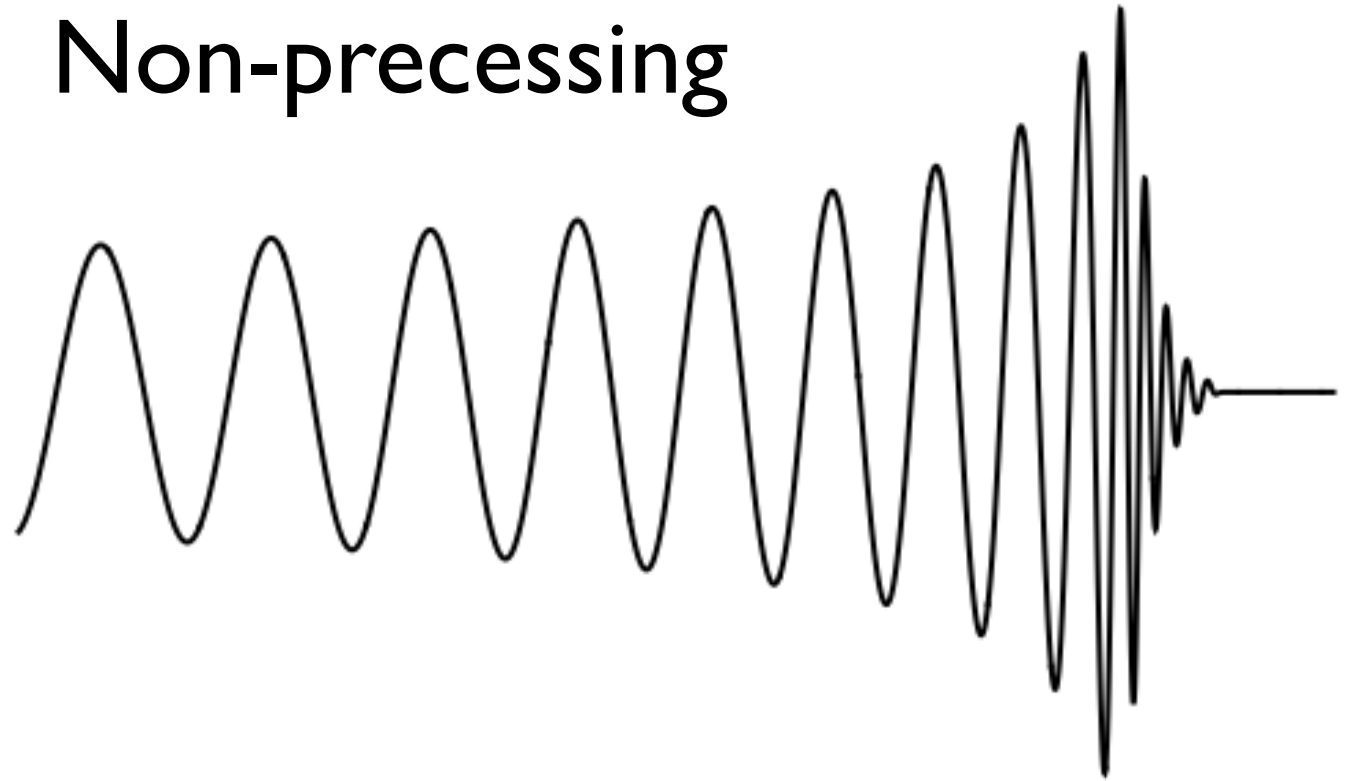


Precessing

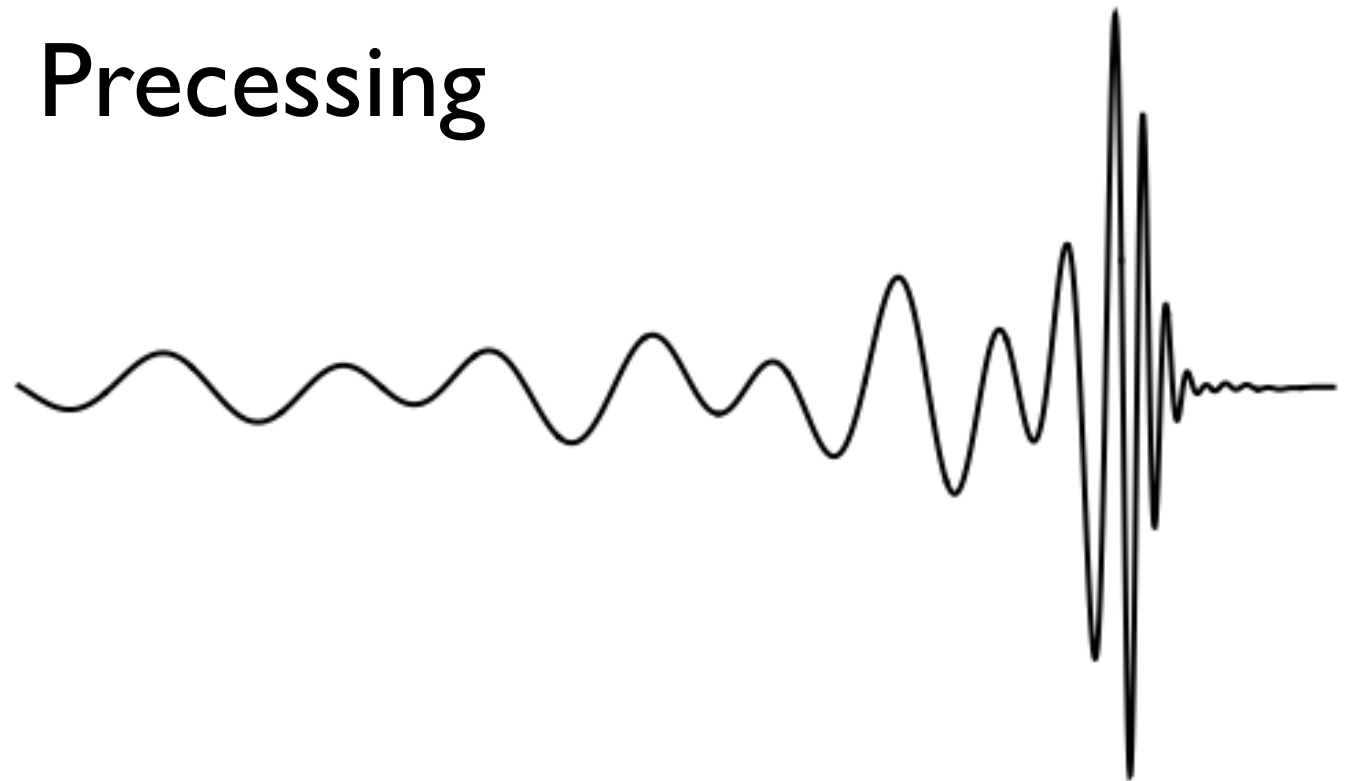


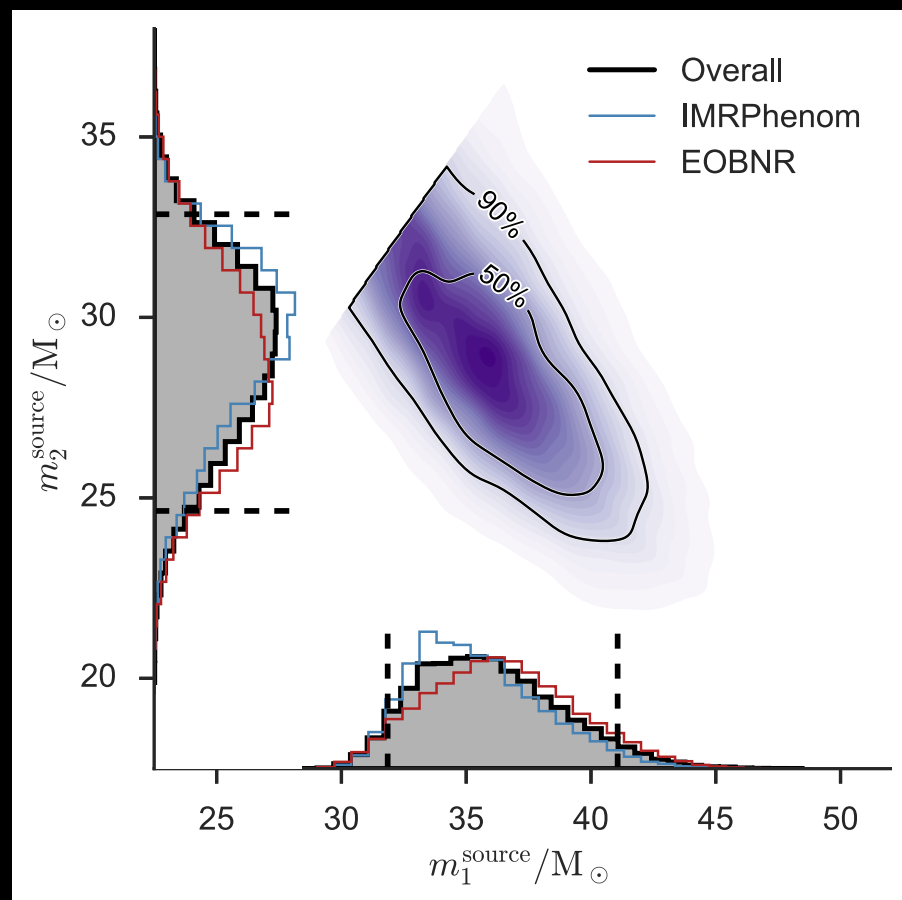
“Edge-on”
to the
source

Non-precessing



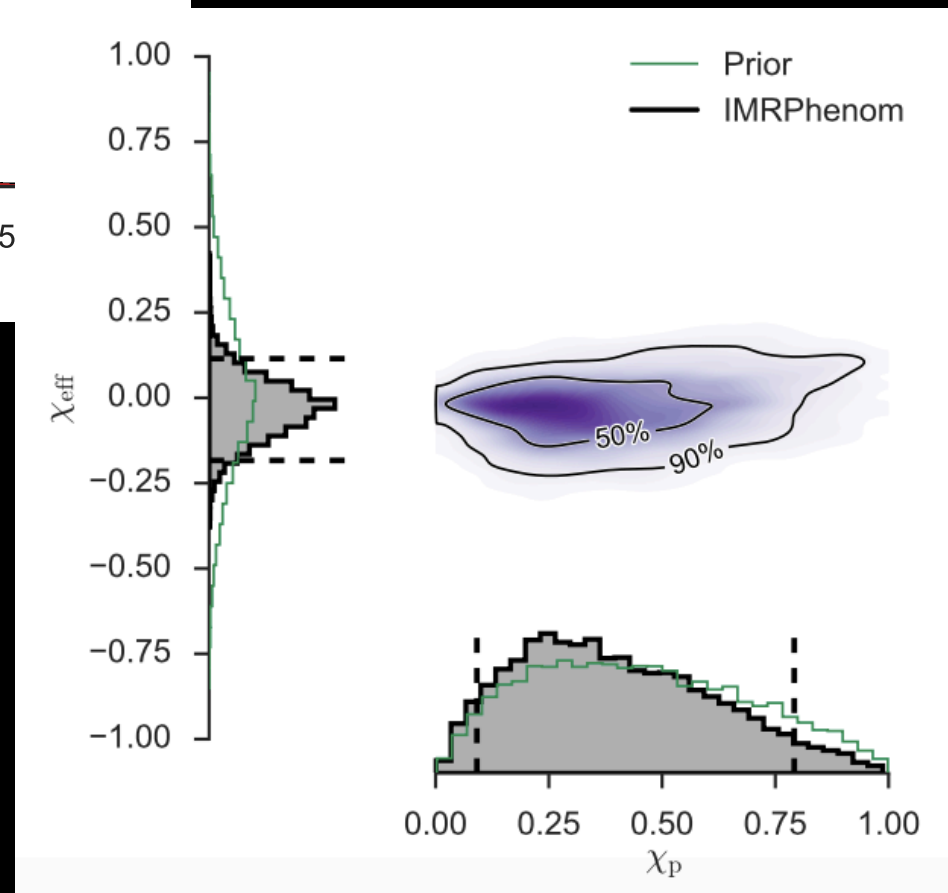
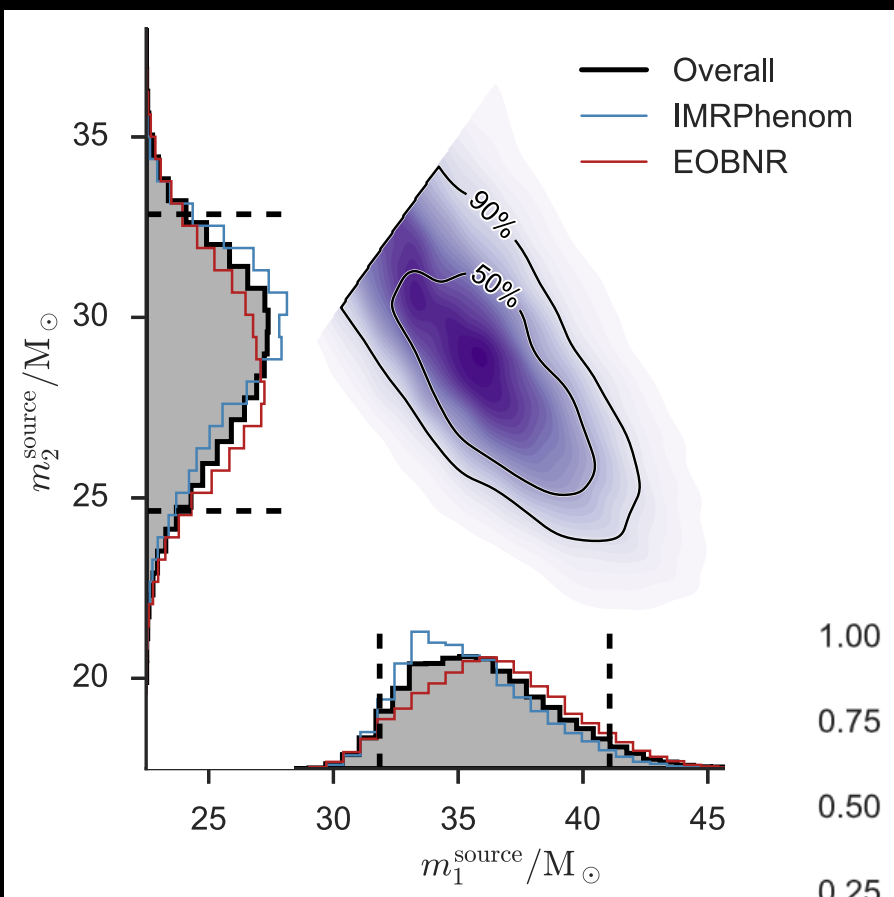
Precessing



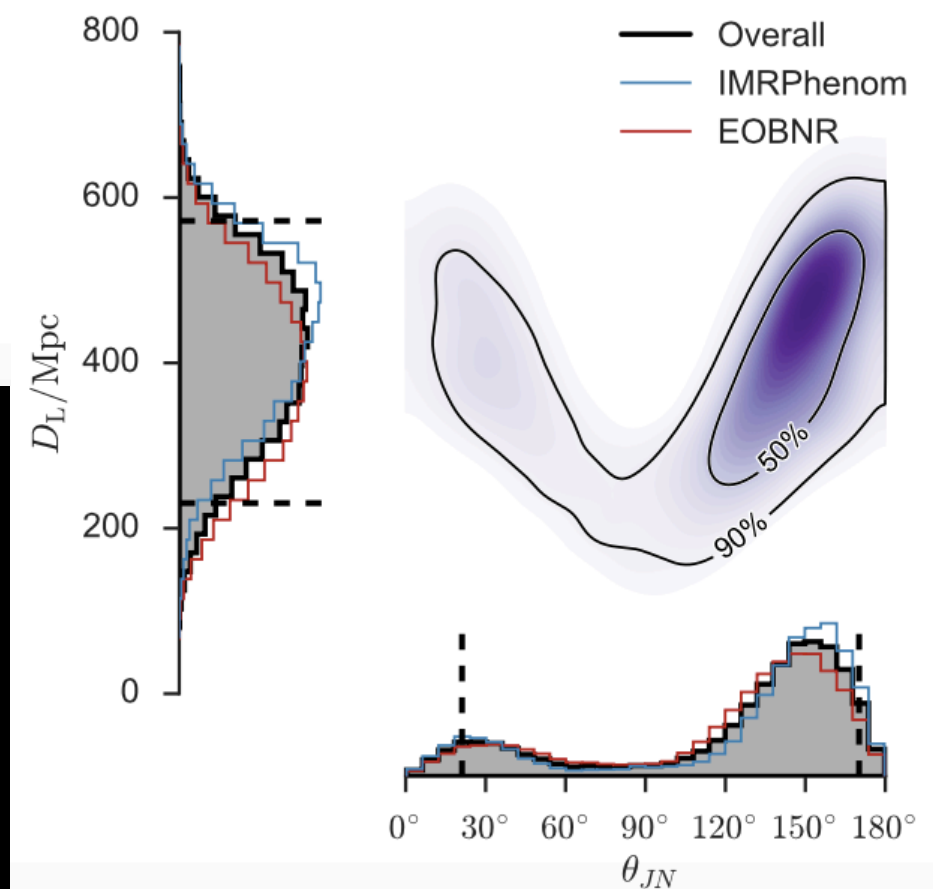
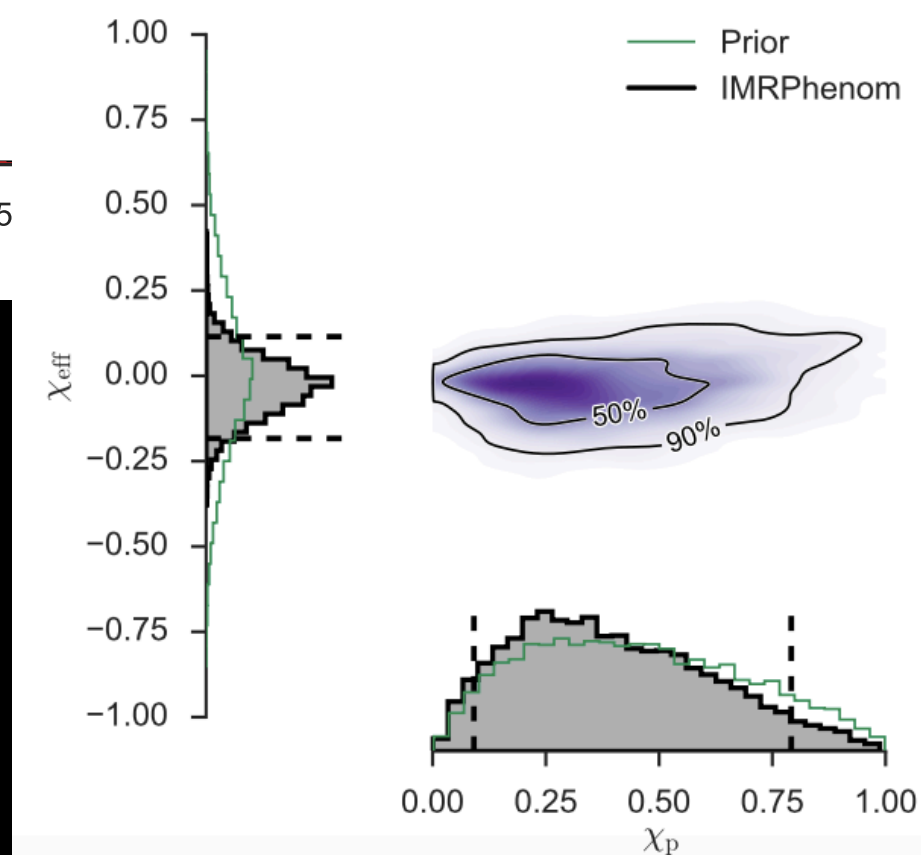
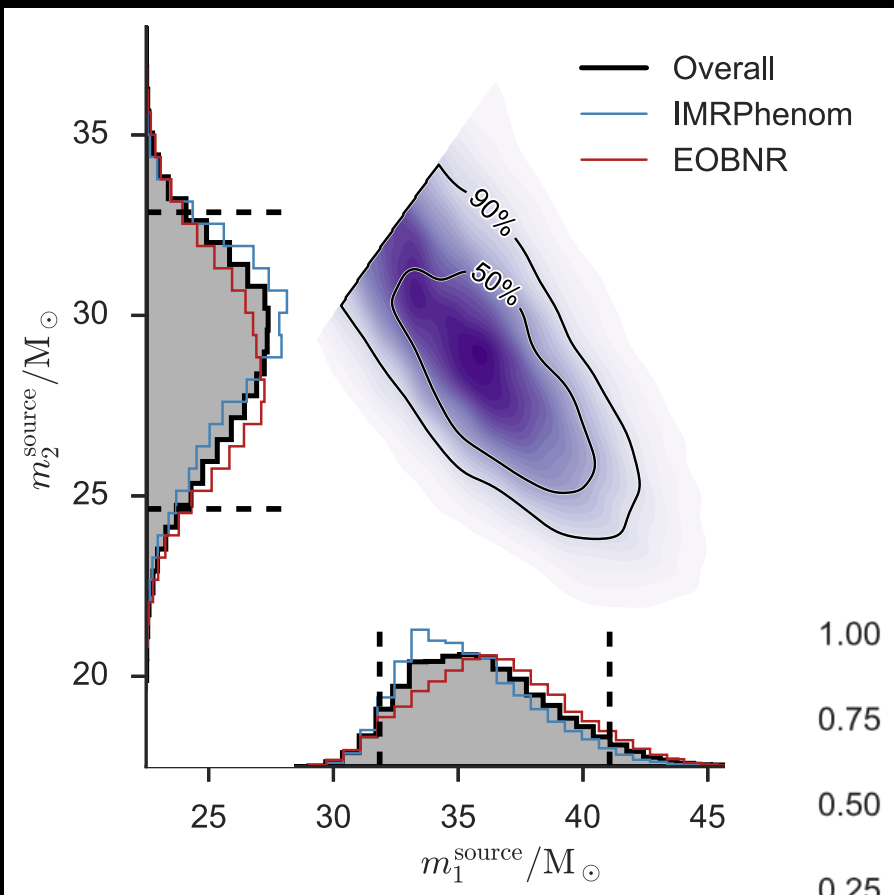


["Properties of the binary black
hole merger GW150914",
LVC (2016)]

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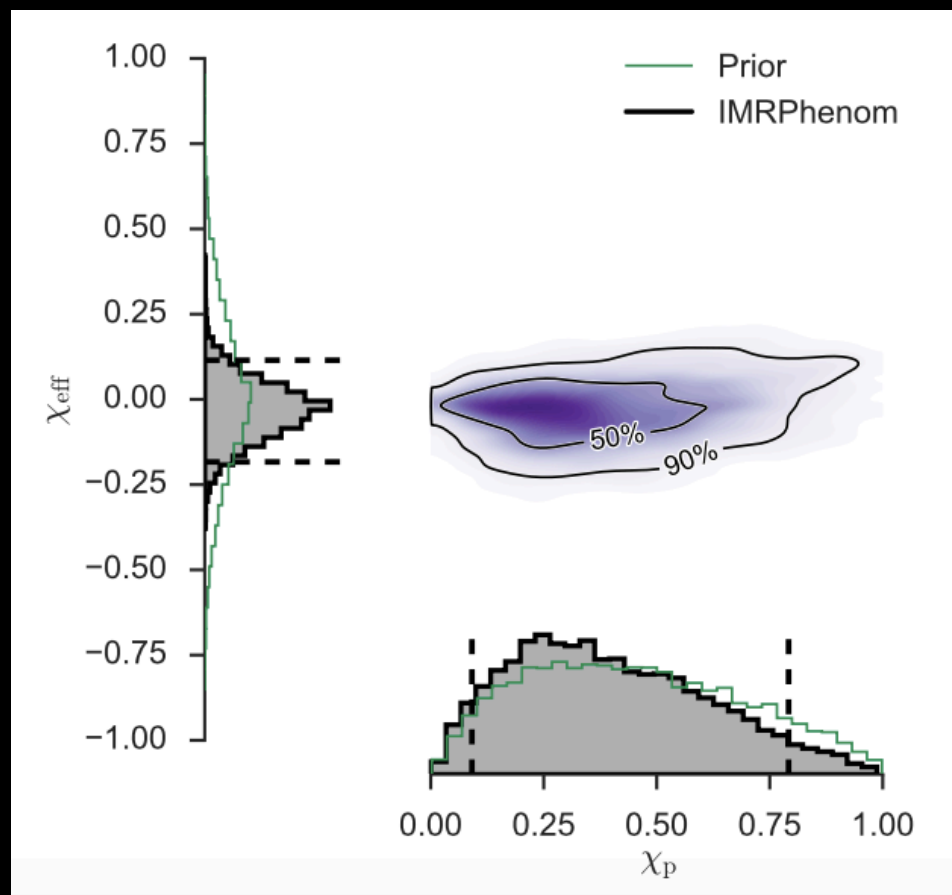
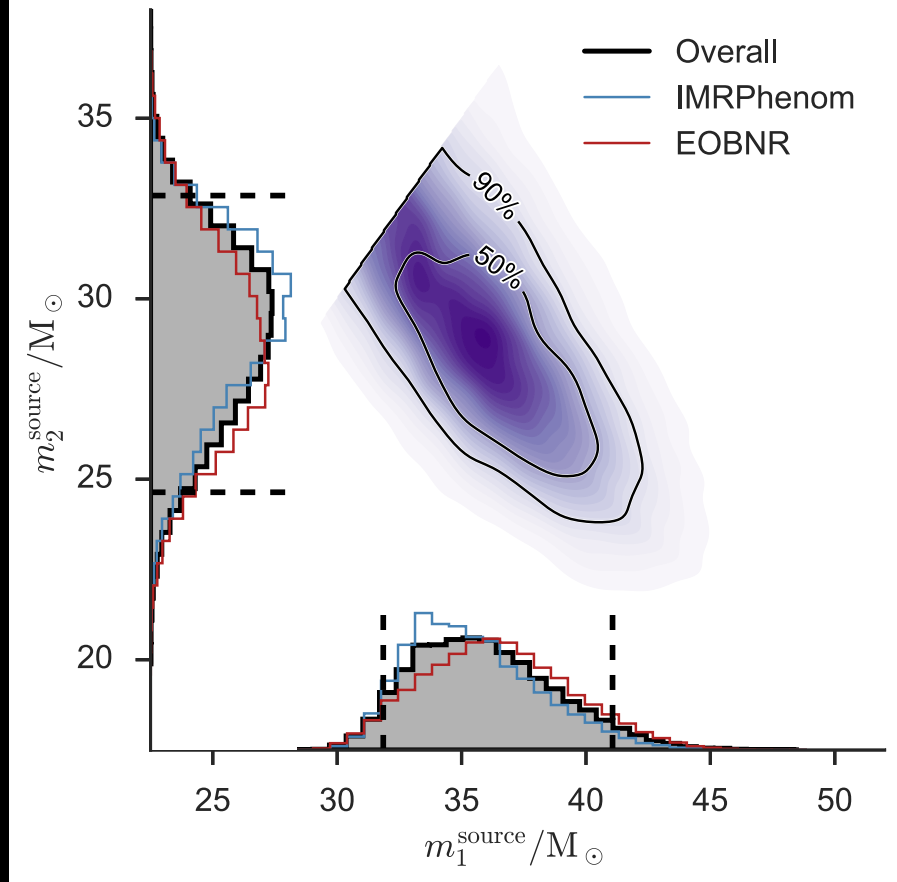


Follow-up simulations

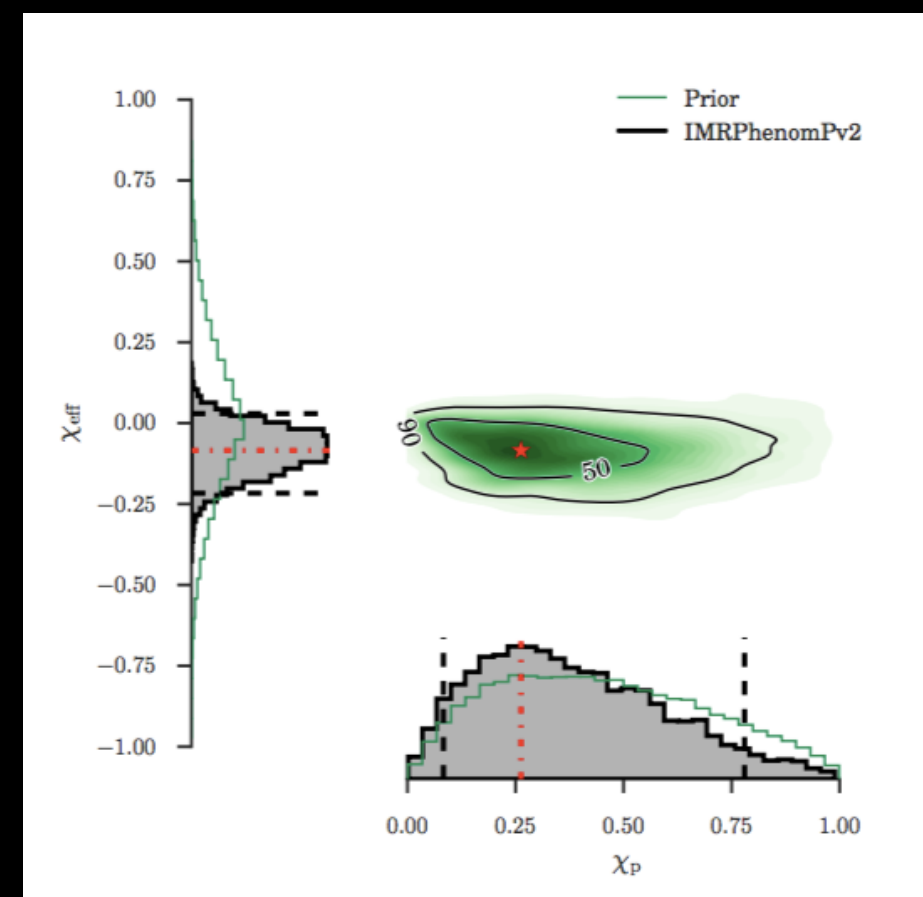
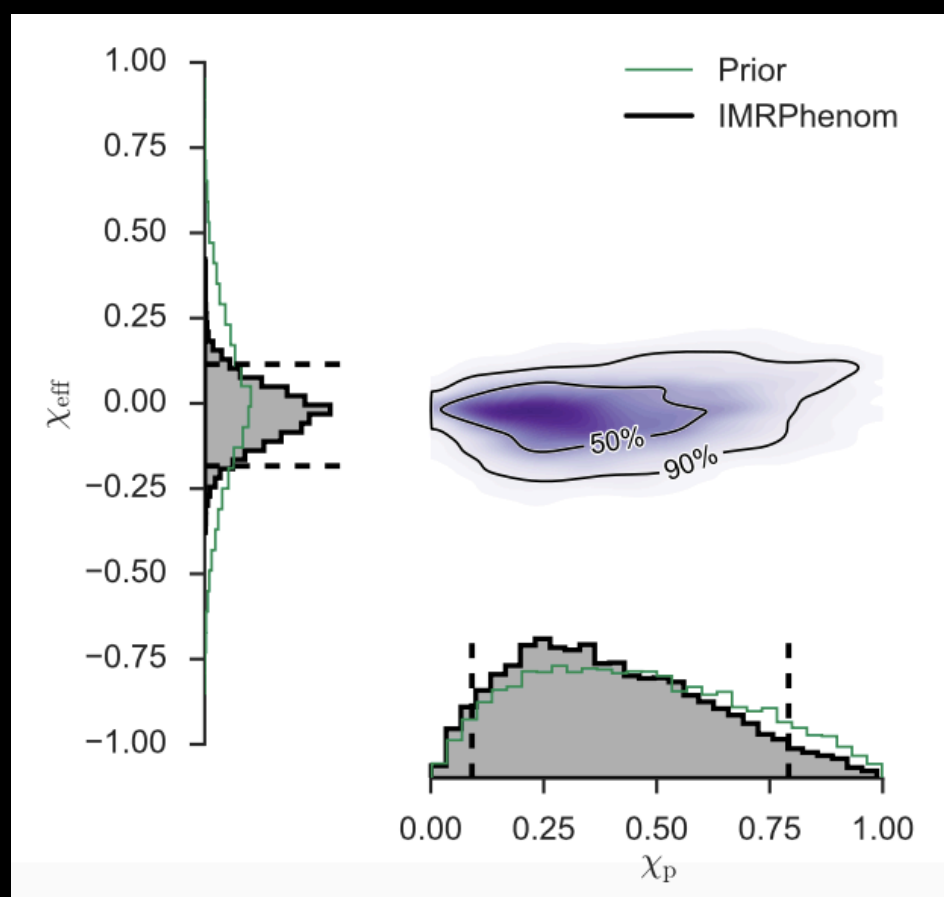
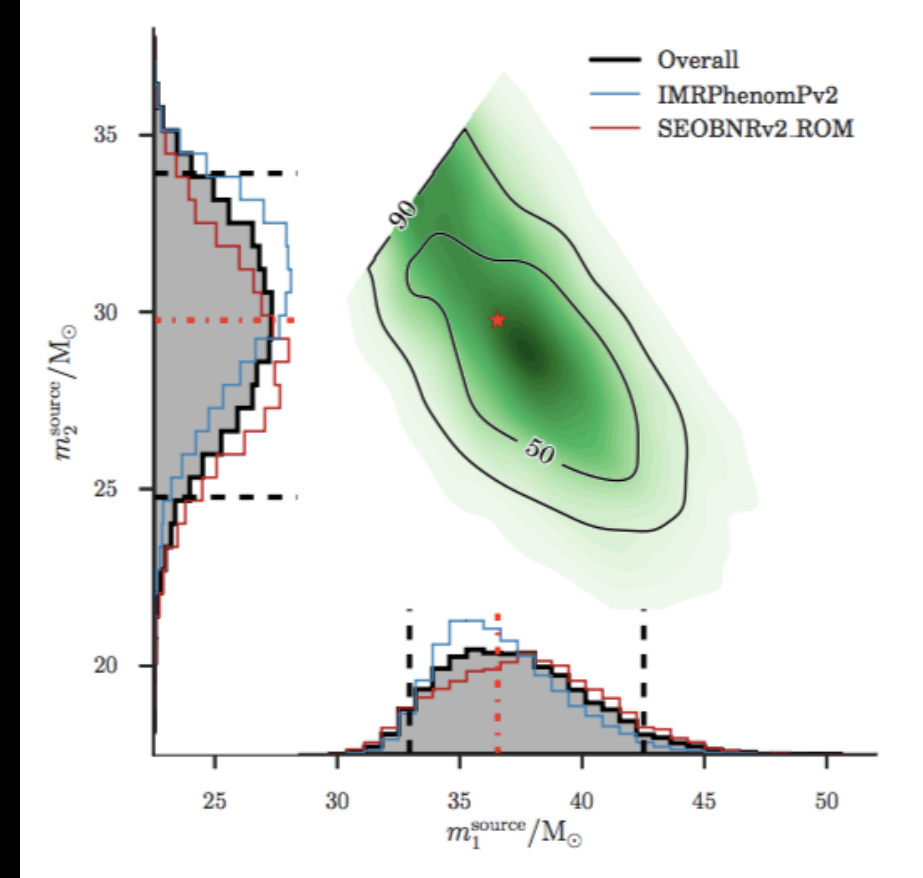
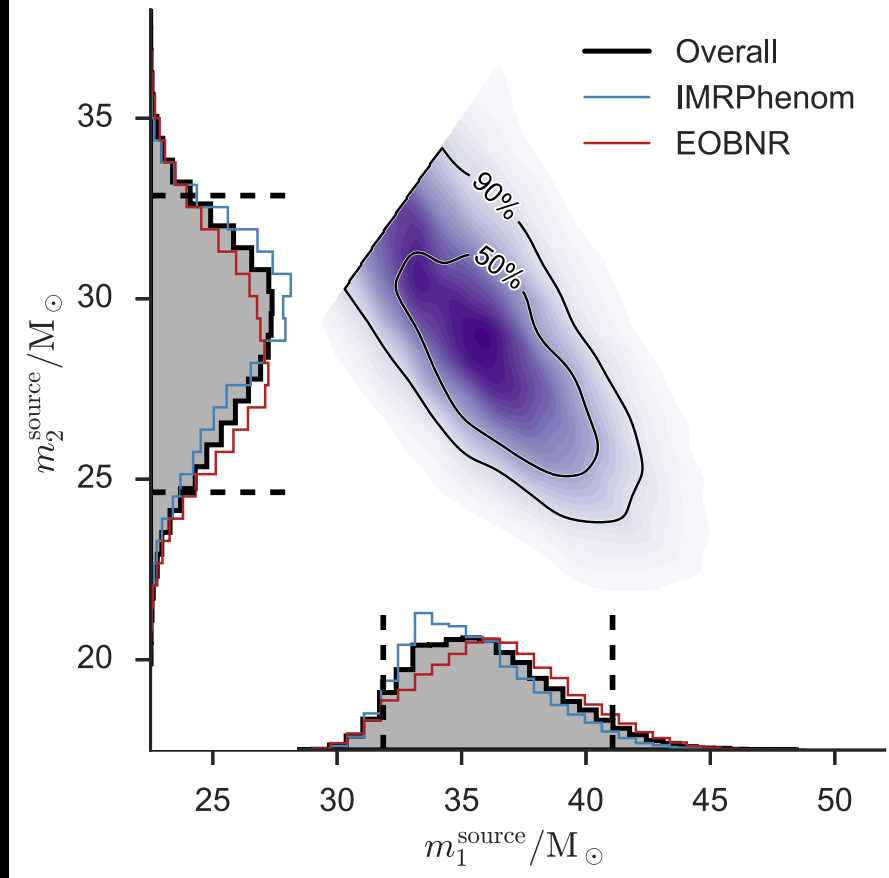
- Perform simulations near “best-guess” parameters
- Study systematic errors in the waveform models
- “Local” models could improve measurements
- 100s of simulations (SXS, Cardiff-UIB, GATech, RIT)
- Relevant to this talk:
 - 14 SXS simulations
 - 3 BAM simulations

(Also see Jonathan Blackman’s talk, Wednesday 2-4pm)

GW150914

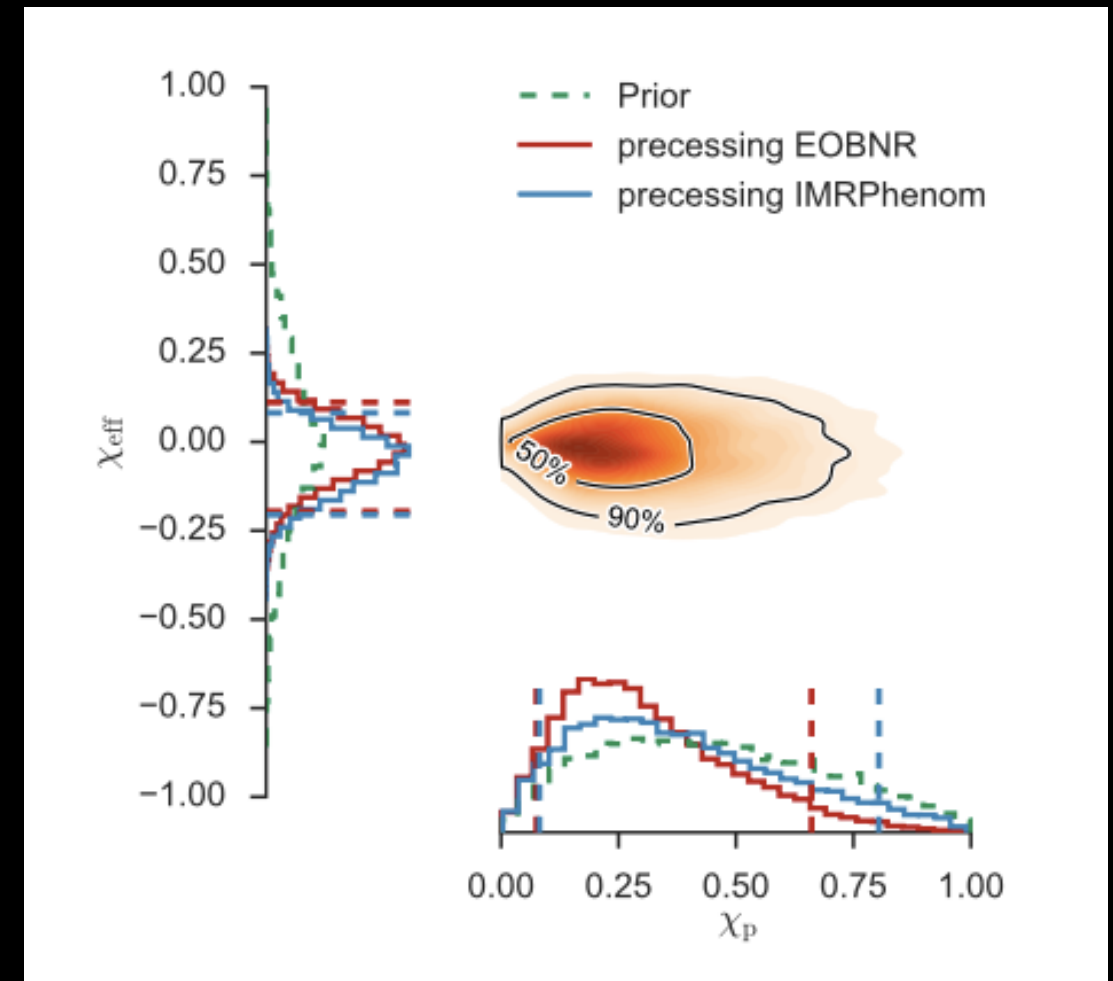
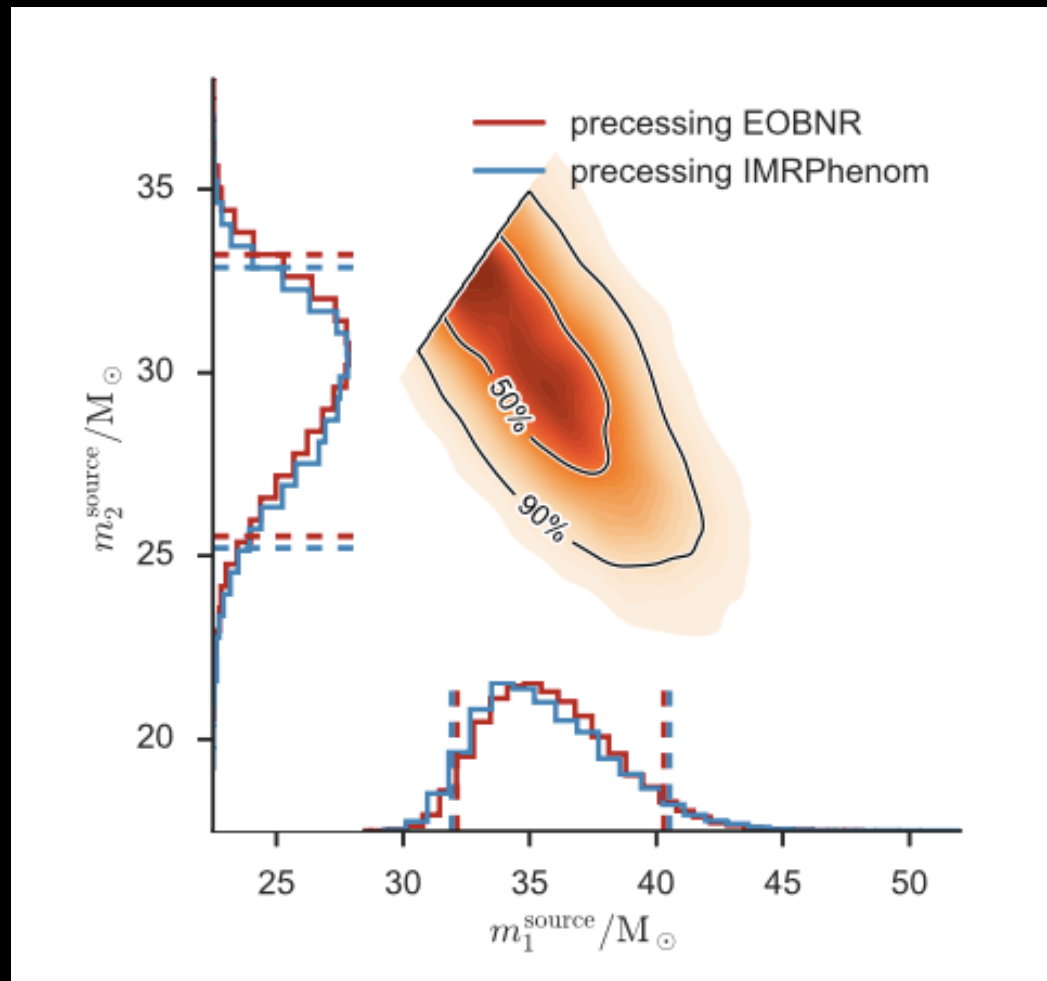


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(See Lionel London's talk, Wednesday 2-4pm)



["An improved analysis of GW150914 using a fully spin-precessing waveform model", LVC, arXiv:1606.01210]

Follow-up simulations

What are the important directions in parameter space?

Around the fiducial “event” parameters:

$$\mathcal{M} = 1 - \sum a_{ij} \Delta x^i \Delta x^j$$

7-dimensional parameter space

Obtain matrix with 28 unique entries

Performed 28+1 simulations with BAM code

Summary

- GW150914 parameters measured using approximate precessing-binary models...
- ... but degeneracies mean that BH spins are difficult to measure (even with full knowledge)
- Follow-up NR simulations suggest that most information *was* extracted from the signal
- Studies with accurate “local” models underway...